Modified Level II Streambed-Scour Analysis for Structure I-70-60-5180 Crossing Branch of McCracken Creek in Hendricks County, Indiana

By BRET A. ROBINSON, DAVID C. VOELKER, and ROBERT L. MILLER

Prepared in cooperation with the INDIANA DEPARTMENT OF TRANSPORTATION

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U.S. DEPARTMENT OF THE INTERIOR BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY Gordon P. Eaton, Director

For additional information, write to:
District Chief
U.S. Geological Survey
Water Resources Division
5957 Lakeside Boulevard
Indianapolis, IN 46278-1996

Copies of this report can be purchased from: U.S. Geological Survey Branch of Information Services Box 25286 Federal Center Denver, CO 80225

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CONVERSION FACTORS AND ABBREVIATIONS

Multiply	Ву	To obtain
inch (in.)	25.4	millimeter
•		minimeter
foot (ft)	0.3048	meter
square foot (ft²)	929.0	square centimeter
feet per second (ft/s)	0.3048	meters per second
cubic foot per second (ft ³ /s)	0.02832	cubic meter per second
mile (mi)	1.609	kilometer
square mile (mi ²)	2.590	square kilometer

Abbreviations used in this report:

D_{50}	median diameter of bed material
Q100	100-year discharge
FEMA	Federal Emergency Management Agency
HEC	Hydraulic Engineering Circular
IDNR	Indiana Department of Natural Resources
INDOT	Indiana Department of Transportation
USGS	U. S. Geological Survey
WSPRO	Water Surface PROfile model

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ABSTRACT

Level II scour evaluations follow a process in which hydrologic, hydraulic, and sediment-transport data are evaluated to calculate the depth of scour that may result when a given discharge is routed through a bridge opening. The results of the modified Level II analysis for structure I-70-60-5180 on Interstate 70 crossing Branch of McCracken Creek in Hendricks County, Indiana, are presented. The site is near the town of Center Valley in the south-central part of Hendricks County. Scour depths were computed with the Water Surface PROfile model, version V050196, which incorporates the scour-calculation procedures outlined in Hydraulic Engineering Circular No. 18. Total scour depths at the piers were approximately 12.4 feet for the modeled discharge of 1,200 cubic feet per second and approximately 24.8 feet for the modeled discharge of 2,040 cubic feet per second.

INTRODUCTION

The U.S. Geological Survey (USGS), in cooperation with the Indiana Department of Transportation (INDOT), is conducting Level II scour analyses at a number of bridges throughout Indiana. This report describes the methods applied and the modeling results for bridge I-70-60-5180.

Background and Scope

Level I scour assessment is a process where a large number of bridges are studied as a group. Assessments usually are made by evaluating a combination of geomorphic, hydrologic, and bridge-characteristic data. The results help investigators determine which bridges appear to be most likely to experience streambed-scour problems and which bridges appear to be relatively immune to problems brought on by streambed scour (for example, bridges built on bedrock).

When applied correctly, Level I scour assessments provide an investigator with information to identify those bridges that appear to be relatively safe and those bridges that fall into higher risk categories.

Level II scour evaluations describe the process for an investigator to apply a model to a bridge site and calculate the potential depth of scour that may result from a given flood event. Level II analyses involve the application of basic hydrologic, hydraulic, and sediment-transport engineering concepts and may include an evaluation of flood history, channel hydraulic conditions (for example, water-surface profile analysis), and basic sediment-transport analyses such as scour calculations (Lagasse and others, 1995).

The methods and model outlined in Hydraulic Engineering Circular (HEC) No. 18 (Richardson and Davis, 1995) formulate the basis for Level II scour evaluations. Methods used in this study for Level II scour evaluations are a modification of the HEC-18 standards. These modifications were made to comply with the methodology requested by INDOT (Merril Dougherty, Indiana Department of Transportation, oral commun., 1996). Descriptions of the specific modifications are given in the "Evaluation Methods" section of this report.

This report presents the methods followed for modeling, special considerations for this study site, and the input for and the output from the Water Surface PROfile (WSPRO) model.

Site Description

The study site is located near the town of Center Valley in the south-central part of Hendricks County. The drainage area for the site is approximately 2.25 mi² (estimated using Hoggatt, 1975, and USGS 7.5-minute topographic data). The predominant land use in the basin is agricultural; in the immediate vicinity of the bridge, the land is predominantly wooded.

Within the immediate vicinity of the bridge, Branch of McCracken Creek has a channel-bed slope of approximately 0.0029 ft/ft. The channel-bed material is sand, and the channel banks consist of silt-clay. At the time of the Level I site visit on June 3, 1991, the banks were observed to have 0 to 10 percent woody vegetative cover; the field report noted that the banks were experiencing some fluvial erosion.

The Interstate 70 crossing of Branch of McCracken Creek is a 72-ft-long, multi-lane bridge consisting of three spans supported by concrete and steel piers and sloping riprap-covered spill-through abutments. Additional details describing conditions at the site are included in the Level I data base (Hopkins and Robinson, unpub. data, 1997). Photographs of the site, taken at the time of the Level I site visit, are archived at the USGS office in Indianapolis.

EVALUATION METHODS

The methods described in this section apply to a number of bridge sites in Indiana being evaluated for scour and outline the procedures requested by INDOT for these modified Level II scour analyses. The principal modification requested by INDOT was that the input data to the model come from or be estimated from existing data sources; no additional field data were collected. Actual methods used in the scour evaluation at this particular bridge site use the most applicable method possible, given the data available.

To determine drainage area, either published values found in Hoggatt (1975) or 7.5-minute topographic maps with Hoggatt's original drainage-area delineations were used. Where there are no published data, drainage-area segments measured from the maps produced by Hoggatt were either subtracted from downstream sites or added to upstream sites published by Hoggatt (1975).

In Indiana, flood discharges are coordinated by agreement among State and Federal agencies. At sites where flood discharges officially are coordinated among State and Federal agencies in Indiana, the coordinated 100-year discharge (Q100) was modeled. INDOT also provided an additional flood discharge for these coordinated sites in excess of the Q100 to be modeled.

If a flood discharge was not coordinated, the USGS examined Federal Emergency Management Agency (FEMA) studies for Q100 determinations. Where FEMA studies did not produce a Q100, the USGS contacted IDNR for an estimated Q100 in the vicinity of the site being studied. If IDNR did not have a Q100, data from nearby USGS streamflow-gaging stations were analyzed with nearby and similar drainage basins that have been coordinated. At sites having no coordinated discharge data, the two discharges used in the model were 1) the approximated Q100 and 2) a discharge equal to 1.7 times the approximated Q100.

Most of the cross-section and bridge-opening geometry data were taken from the bridge plans (Indiana State Highway Commission, 1964) provided by INDOT. Bridge plans are presumed to be representative of current conditions at the site. To determine the cross-section geometry, a line was drawn on the bridge plans parallel to the bridge stationing and approximately one bridge width from the bridge. For sites where the bridge plans did not extend far enough laterally for collection of all cross-section data required for WSPRO model analysis, additional data were collected from 7.5-minute topographic maps.

The roadway and embankment profile was taken from the bridge and highway plans for those sites where roadway overtopping was expected. The INDOT bridge plans and 7.5-minute topographic maps were used as a guide, based on the water-surface elevations calculated by the WSPRO model, to determine if roadway overtopping might occur.

Roughness values (*n*-values) for the main channel were estimated by viewing photographs archived from the Level I scour assessments. The *n*-values for the overbanks were assigned on the basis of the surface-cover data summarized in the Level I data base (Hopkins and Robinson, unpub. data, 1997). From those data, the following roughness values were assigned to the surface-cover categories: urban—0.050, suburban—0.035, row crop—0.045, pasture—0.035, brush—0.120, forest—0.100, and wetland (any area covered by standing water)—0.100. The *n*-values for the overbanks were adjusted if the Level I photographs provided sufficient detail to warrant an adjustment.

WSPRO version V050196 was used to model flow through the study site. Starting watersurface elevation was obtained with a slope-conveyance computation. The channel-bed slope in the immediate vicinity of the bridge was estimated from the 7.5-minute topographic map and was used as the slope of the energy grade line for this computation.

WSPRO version V050196 includes a field that allows the input of up to four scour-adjustment factors (K1 to K4). For this modeling, the default value for K4 (bed armoring) was chosen. For scour-adjustment factors K1 and K2 (pier-nose shape and angle of attack, respectively), input values were determined by evaluating the data archived in the Level I data base (Hopkins and Robinson, unpub. data, 1997). For the K3 factor (bed forms), a value of 1.1 was applied in all cases.

In some cases, piers set on the overbanks are constructed with footings that are higher in elevation than pier footings in the main channel. In these situations, if the channel position changes, the piers that were initially constructed on the overbank may become part of the main channel. Therefore, to evaluate total potential scour, the model results obtained for contraction scour and deepest local scour in the main channel were added and applied to all piers in the bridge opening. This methodology allowed for an evaluation of potential undermining of pier supports in the event that future channel movement placed overbank piers in the main channel.

Where bridge pairs have a continuous abutment or fill between the bridges that does not allow expansion of flow, the bridge pair was modeled as one bridge. Sites with discontinuous abutments, allowing expansion between the bridges, were modeled as two separate bridges. In those cases, a valley cross section was measured between the bridges and used as the approach section for the downstream bridge and as the exit section for the upstream bridge.

At sites with no embankment to function as a weir or at sites where the tailwater drowns out the embankment, a composite bridge and road section was used to compute flow. Those sites were computed with friction-loss equations rather than with a bridge routine.

Total scour is taken as the sum of local scour plus contraction scour. If the model predicted negative contraction scour (aggradation), the contraction-scour value was assumed to be zero in determining the total scour depth (table 1). This assumption was made so that a negative contraction scour would not mask the potentially detrimental effects of local scour at a pier. No abutment scour evaluations were made in this study.

Table 1. Cumulative scour depths for the modeled discharges at structure I-70-60-5180 crossing Branch of McCracken Creek in Hendricks County, Indiana [--, no value]

Pier number ¹	Stationing from bridge pians ²	initiai bed- eievation at pier (feet)	Main- channei contrac- tion scour depth (feet)	Locai scour depth (feet)	Worst- case totai- scour depth ³ (feet)	Bottom elevation of pier (feet)	Worst- case bed elevation after scour ⁴ (feet)
		Modeled	discharge ⁵ is 1,2	00 cubic feet p	per second		
1	591+98	750	7.8	4.6	12.4	740.0	733.6
2	592+25	750	7.8	4.6	12.4	740.0	733.6
		Modeled	discharge is 2,04	40 cubic feet p	er second		
1	591+98	750	19.5	5.3	24.8	740.0	721.2
2	592+25	750	19.5	5.3	24.8	740.0	721.2

¹Pier numbers were assigned from left to right as shown on the bridge plans.

²Stationing is the center line of the pier as determined from the bridge plans. Stationing from bridge plan, 591+98, represents a point 59,198 feet from an arbitrary starting location referenced on the bridge plans.

³Worst-case total-scour depths are generated by summing the calculated contraction-scour depth with the worst case of local scour.

⁴Worst-case bed elevation is computed by subtracting the worst-case total-scour depth from the lowest initial bed elevation in the bridge opening (746.0 feet).

⁵Not a coordinated discharge.

SPECIAL CONSIDERATIONS

Model runs indicate the water-surface elevation at the bridge is lower than the low-steel elevation for the modeled discharges. Therefore, there should be no pressure flow through the bridge opening for the discharges modeled.

RESULTS

Scour depths were computed with a version of WSPRO (Larry Arneson, Federal Highway Administration, written commun., 1996) modified from Shearman (1990). This version of WSPRO includes scour calculations in the model output. Scour depths were calculated assuming an infinite depth of material that could erode and a homogeneous particle-size distribution. The results of the scour analysis are presented in table 1; a complete input file and output results are presented in the appendix.

REFERENCES

- Hoggatt, R.E., 1975, Drainage areas of Indiana streams: U.S. Geological Survey, Water Resources Division, 231 p.
- Indiana State Highway Commission, 1964, Bridge plans Interstate Route 70: Bridge File I-70-60-5180.
- Lagasse, P.F.; Schall, J.D.; Johnson, F.; Richardson, E.V.; and Chang, F., 1995, Stream stability at highway structures (2d ed.): Federal Highway Administration, Hydraulic Engineering Circular No. 20, Publication FHWA-IP-90-014, 144 p.
- Richardson, E.V., and Davis, S.R., 1995, Evaluating scour at bridges (3d ed.): Federal Highway Administration, Hydraulic Engineering Circular No. 18, Publication FHWA-IP-90-017, 204 p.
- Shearman, J.O., 1990, User's manual for WSPRO, a computer model for water-surface profile computations: Federal Highway Administration Publication FHWA-IP-89-027, 177 p.

APPENDIX

WSPRO INPUT FILE

```
T1
          I-70 Over Br. McCracken Creek
                                           I70-60-5180
Т2
          County: Hendricks
                                           Quad: Mooresville West
Т3
          02-20-97
                                           Bret A. Robinson
SI
          0
Q
          1200 2040
SK
          .0029 .0029
XS
     EXIT 0 0
GR
          58847 760
                    58918 762 58935 759 58961 758 58978 757
          59003 756
                    59009 755 59020 753 59051 752 59101 751
GR
                    59186 751
                              59201 746
GR
          59141 751
                                         59219 746
                   59241 752 59286 755 59299 756 59323 757
GR
          59231 751
GR
          59474 765
                    59495 770 59742 770 59814 770 60020 780
GR
          60269 780 60363 780
                          .100
          .100
                   .034
N
            59190
                     59225
SA
    FULLV77 0
XS
GR
          58847 760 58918 762
                               58935 759
                                         58961 758 58978 757
          59003 756 59009 755
                               59020 753
                                         59051 752
GR
                                                     59101 751
                    59186 751
GR
          59141 751
                               59201 746 59219 746 59228 750
                    59241 752 59286 755 59299 756 59323 757
          59231 751
GR
         59474 765 59495 770 59742 770 59814 770 60020 780
GR
GR
          60269 780 60363 780
N
          .100
                   .034
                            .100
                    59225
SA
             59190
    BRDGE77 759 0
BR
         59175 0759.2 59175 0758.6 59178 0758.6 59205 0745.9
GR
GR
         59218 0745.9 59241 0758.6 59244 0758.6 59244 0759.3
         59208 0759.2 59175 0759.2
GR
          .045
                  .034
N
                           .045
           59205
                    59218
SA
         750 3 1
PD
         3 135 2 758.5
CD
          LXBr RXBr * * * TPierW
DC 0 BRDGE 59194 59228 59197 59256 * 3
         LPierEdge RPierEdge PierWdth * * K1 K2 K3(1.1)
         59175 59244 1.5 * * 1 1 1.1
DP
         59175 59244 1.5 * * 1 1 1.1
DΡ
    APPR 289 0
XS
         58261 770 58503 770 58951 762 58958 761 59008 756
GR
         59044 753
                    59197 752
                              59205 751 59210 747
                                                     59216 747
GR
         59232 748
                    59246 749
                              59256 751 59272 752
                                                    59297 752
GR
         59307 752 59316 752 59318 752 59324 752 59339 752
GR
         59426 758 59447 760 59504 770 59884 770 60107 780
GR
         .100
                  .034
                          .100
N
                    59200
SA
           59175
EX
ER
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		RO *******	*****
Federal	Highway Administration	- U. S. Geo	logical Survey
	Model for Water-Surface		
	te & Time: 8/6/97 6		
	File: 5180.dat		
	OVER BR. MCCRACKEN CR		
T2 COUN			MOORESVILLE WEST
T3 02-2			. ROBINSON
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SI 0	2040		
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*** Process	ing Flow Data; Placing	Information i	nto Sequence 1 ***
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	Highway Administration		
	odel for Water-Surface		
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02-20	-97	BRET A. F	ROBINSON
	Starting To Process F		
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XS EXIT 0 0			
GR 5884	7 760 58918 762 58935		
GR 5884	7 760 58918 762 58935 3 756 59009 755 59020		
GR 5884 GR 5900		753 59051 7	52 59101 751
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GR 5884 GR 5900 GR 5914 GR 5923 GR 5947 GR 6026 N .100 SA 59 *** Complet *** Storing *** SRD Location: Valley Slope: Energy Loss C	3 756 59009 755 59020 1 751 59186 751 59203 1 751 59241 752 59286 4 765 59495 770 59742 9 780 60363 780	2 753 59051 75 1 746 59219 75 2 755 59299 75 2 770 59814 75 2 2 770 59814 75 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	52 59101 751 46 59228 750 56 59323 757 70 60020 780 er Record EXIT *** Record Number 1 *** XIT *** .0 Error Code 0 Geometric Mean. Contraction: .00 X Y 58935.000 759.000

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746.000
                     59219.000
                                746.000
 59201.000
                                        59228,000
                                                     750.000
                               752.000 59286.000
 59231.000
            751.000 59241.000
                                                     755.000
                               757.000
 59299.000
            756.000 59323.000
                                        59474.000
                                                     765.000
 59495.000
            770.000
                    59742.000
                               770.000
                                        59814.000
                                                     770.000
 60020.000
            780.000
                    60269.000
                                780.000
                                        60363.000
                                                     780,000
              Minimum and Maximum X, Y-coordinates
 Minimum X-Station: 58847.000 (associated Y-Elevation: 760.000)
 Maximum X-Station: 60363.000 (associated Y-Elevation: 780.000)
 Minimum Y-Elevation: 746.000 (associated X-Station: 59219.000)
 Maximum Y-Elevation: 780.000 (associated X-Station: 60020.000)
                Roughness Data ( 3 SubAreas )
                      Roughness Horizontal
              SubArea Coefficient Breakpoint
                     ------
                         .100
                         - - -
                         .034
                 2
                         - - -
                 3
                         .100
       *-----*
             Finished Processing Header Record EXIT
       *----*
  ******************* W S P R O ***************
     Federal Highway Administration - U. S. Geological Survey
          Model for Water-Surface Profile Computations.
         Input Units: English / Output Units: English
  *-----*
        I-70 OVER BR. MCCRACKEN CREEK
                                  I70-60-5180
    COUNTY: HENDRICKS
                              QUAD: MOORESVILLE WEST
       02-20-97
                                 BRET A. ROBINSON
            Starting To Process Header Record FULLV
       *----*
    FULLV77 0
XS
GR
        58847 760 58918 762 58935 759 58961 758 58978 757
        59003 756 59009 755 59020 753 59051 752 59101 751
GR
        59141 751 59186 751 59201 746 59219 746 59228 750
GR
        59231 751 59241 752 59286 755 59299 756 59323 757
GR
        59474 765 59495 770 59742 770 59814 770 60020 780
GR
GR
        60269 780 60363 780
        .100 .034 .100
N
SA
          59190 59225
    Completed Reading Data Associated With Header Record FULLV
```

*** Storing X-Section Data In Temporary File As Record Number 2 ***

***	Data Su	mmary For H	eader Record	FULLV	***
SRD Location		_		.0 Error C	ode 0
				By Geometric M	
				Contraction:	
	Х, Y-	coordinates	(27 pairs)		
X	Y	Х	Y	X	Y
58847.000	760.000	58918.000	762.000	58935.000	759.000
58961.000	758.000	58978.000	757.000	59003.000	756.000
59009.000	755.000	59020.000	753.000	59051.000	752.000
59101.000	751.000	59141.000	751.000	59186.000	751.000
59201.000	746.000	59219.000	746.000	59228.000	750.000
59231.000	751.000	59241.000	752.000	59286.000	755.000
59299.000	756.000	59323.000	757.000	59474.000	765.000
59495.000	770.000	59742.000	770.000	59814.000	770.000
60020.000	780.000	60269.000	780.000	60363.000	780.000
			X,Y-coordina		
				-Elevation: 70	
				-Elevation: 78	
				-Station: 5921	
Maximum Y-	Elevation:	780.000 (a	associated X	-Station: 6002	20.000)
	Rough		3 SubAreas		
		-	s Horizonta		
	SubArea		nt Breakpoi	nt	
				• •	
	1	.100			
	_		*****	*	
	2	.034			
			*****	*	
	3	.100			
*					
*		_	Header Record		
*				-	
		+++ M C D I		****	
redela				eological Surve	= y
	Model for Wa Input Units:		_		
*	_		_	s: Engilsn	*
т.	-70 OVER BR. M				
	: HENDRICKS	CCRACKEN CR.		RESVILLE WEST	
	20-97		•	ROBINSON	
02-	20) !		DREI A.	TODINON	
*				*	
*			Header Record		
*					

BR BRDGE77 759 0

```
59175 0759.2 59175 0758.6 59178 0758.6 59205 0745.9
 GR
 GR
          59218 0745.9 59241 0758.6 59244 0758.6 59244 0759.3
          59208 0759.2 59175 0759.2
 GR
 N
               .034
                         .045
 SA
           59205
                   59218
 PD
          750 3 1
 CD
          3 135 2 758.5
       Completed Reading Data Associated With Header Record BRDGE ***
+++072 NOTICE: X-coordinate # 2 increased to eliminate vertical segment.
+++072 NOTICE: X-coordinate # 8 increased to eliminate vertical segment.
  *** Storing Bridge Data In Temporary File As Record Number 3
  * * *
                 Data Summary For Bridge Record BRDGE
                 77. Cross-Section Skew: .0 Error Code 0
  SRD Location:
  Valley Slope: ******
                        Averaging Conveyance By Geometric Mean.
  Energy Loss Coefficients -> Expansion: .50 Contraction: .00
                    X,Y-coordinates (10 pairs)
               Y
                   X
                                      Y
     Х
                                  -----
                                             -----
                       -----
 ------
           ------
              759.200
                        59175.100
                                     758.600
                                              59178.000
                                                           758.600
  59175.000
                                   745.900
  59205.000
               745.900 59218.000
                                              59241.000
                                                           758.600
                      59244.100 759.300
  59244.000
               758.600
                                              59208.000
  59175.000
               759.200
                Minimum and Maximum X, Y-coordinates
   Minimum X-Station: 59175.000 (associated Y-Elevation: 759.200)
   Maximum X-Station: 59244.100 (associated Y-Elevation: 759.300)
   Minimum Y-Elevation: 745.900 (associated X-Station: 59218.000)
   Maximum Y-Elevation: 759.300 (associated X-Station: 59244.100)
                   Roughness Data ( 3 SubAreas )
                         Roughness Horizontal
                 SubArea Coefficient Breakpoint
                         -----
                             .045
                             - - -
                                     ******
                    2
                             .034
                             - - -
                             .045
                    3
                 Discharge coefficient parameters
              BRType BRWdth EMBSS EMBElv UserCD
               3
                     135.000 2.00 758.500 *******
                     Pressure flow elevations
                       AVBCEL
                                PFElev
                                759,000
```

Abutment Parameters
ABSLPL ABSLPR XTOELT YTOELT XTOERT YTOERT

Pier/Pile Data (1 Group(s)) Code Indicates Bridge Uses Piers Group Elevation Gross Width Number 1 750.000 3.000 1 * Finished Processing Header Record BRDGE * * * *******************************
Code Indicates Bridge Uses Piers Group Elevation Gross Width Number 1 750.000 3.000 1 * Finished Processing Header Record BRDGE * **********************************
Group Elevation Gross Width Number 1 750.000 3.000 1 *********************************
1 750.000 3.000 1 * Finished Processing Header Record BRDGE * * Finished Processing Header Record BRDGE * **********************************
* Finished Processing Header Record BRDGE * **********************************
* Finished Processing Header Record BRDGE * **********************************
* Finished Processing Header Record BRDGE * **********************************

Federal Highway Administration - U. S. Geological Survey
Federal Highway Administration - U. S. Geological Survey
Input Units: English / Output Units: English *
* I-70 OVER BR. MCCRACKEN CREEK I70-60-5180 COUNTY: HENDRICKS QUAD: MOORESVILLE WEST 02-20-97 BRET A. ROBINSON DC 0 BRDGE 59194 59228 59197 59256 * 3 DP 59175 59244 1.5 * * 1 1 1.1 DP 59175 59244 1.5 * * 1 1 1.1 * * Starting To Process Header Record APPR * * * Starting To Process Header Record APPR * * * ** XS APPR 289 0 GR 58261 770 58503 770 58951 762 58958 761 59008 756 GR 59044 753 59197 752 59205 751 59210 747 59216 747 GR 59232 748 59246 749 59256 751 59272 752 59297 752
I-70 OVER BR. MCCRACKEN CREEK I70-60-5180 COUNTY: HENDRICKS QUAD: MOORESVILLE WEST - 02-20-97 BRET A. ROBINSON DC 0 BRDGE 59194 59228 59197 59256 * 3 DP
02-20-97 BRET A. ROBINSON DC 0 BRDGE 59194 59228 59197 59256 * 3 DP
DC 0 BRDGE 59194 59228 59197 59256 * 3 DP
DP 59175 59244 1.5 * * 1 1 1.1 DP 59175 59244 1.5 * * 1 1 1.1 * Starting To Process Header Record APPR * * Starting To Process Header Record APPR * *** XS APPR 289 0 GR 58261 770 58503 770 58951 762 58958 761 59008 756 GR 59044 753 59197 752 59205 751 59210 747 59216 747 GR 59232 748 59246 749 59256 751 59272 752 59297 752
DP 59175 59244 1.5 * * 1 1 1.1 ****** * Starting To Process Header Record APPR * * * * * * * * * * * * * * * * * *
* Starting To Process Header Record APPR * ****** XS APPR 289 0 GR 58261 770 58503 770 58951 762 58958 761 59008 756 GR 59044 753 59197 752 59205 751 59210 747 59216 747 GR 59232 748 59246 749 59256 751 59272 752 59297 752
* Starting To Process Header Record APPR * ****** XS APPR 289 0 GR 58261 770 58503 770 58951 762 58958 761 59008 756 GR 59044 753 59197 752 59205 751 59210 747 59216 747 GR 59232 748 59246 749 59256 751 59272 752 59297 752

GR 58261 770 58503 770 58951 762 58958 761 59008 756 GR 59044 753 59197 752 59205 751 59210 747 59216 747 GR 59232 748 59246 749 59256 751 59272 752 59297 752
GR 58261 770 58503 770 58951 762 58958 761 59008 756 GR 59044 753 59197 752 59205 751 59210 747 59216 747 GR 59232 748 59246 749 59256 751 59272 752 59297 752
GR 59044 753 59197 752 59205 751 59210 747 59216 747 GR 59232 748 59246 749 59256 751 59272 752 59297 752
GR 59232 748 59246 749 59256 751 59272 752 59297 752
GR 59307 752 59316 752 59318 752 59324 752 59339 752
GR 59426 758 59447 760 59504 770 59884 770 60107 780
N .100 .034 .100
SA 59175 59200
*** Completed Reading Data Associated With Header Record APPR ***
*** Storing X-Section Data In Temporary File As Record Number 4 ***
*** Data Summary For Header Record APPR ***
*** Data Summary For Header Record APPR *** SRD Location: 289. Cross-Section Skew: .0 Error Code 0
Valley Slope: .00000 Averaging Conveyance By Geometric Mean.
Energy Loss Coefficients -> Expansion: .50 Contraction: .00
X,Y-coordinates (25 pairs)
X Y X Y X Y
58261.000 770.000 58503.000 770.000 58951.000 762.000 58858.000 761.000 58008.000 756.000 589044.000 753.000
58958.000 761.000 59008.000 756.000 59044.000 753.000 59197.000 752.000 59205.000 751.000 59210.000 747.000
- 37177,000

5925	6.000	751.000	59272.000	752.00	59297.0	00 752.000
	7.000		59316.000			
	4.000	752.000	59339.000	752.00		
	7.000		59504.000			00 770.000
6010	7.000	780.000				
				m X,Y-coord		
					Y-Elevation	
					Y-Elevation	
Min	imum Y-El	evation:	747.000 (associated	X-Station: X-Station:	59216.000)
Max	ımum Y-El	evation:	780.000 (associated	x-Station:	60107.000)
		Rough	ness Data	(3 SubArea	as)	
		110491		ss Horizon		
		SubArea		ent Breakpo		
		1	.100			
				****	***	
		2	.034			
				****	***	
		3	.100	• • •		
					·	
Pridao	datum nro	ioation(s).	י ייינים שמע	XREFRT FDS	יים די מייטיי	
Briage	datum pro) CC C I OII (B / .		***** ***		
	*					*
	*	Finished	Processing	Header Reco	ord APPR	*
	*					*
**						
					Geological Somputations.	survey
					ts: English	
* -			=	_		*
	I-70	OVER BR. N	CCRACKEN C	REEK 170	-60-5180	
	COUNTY: H				ORESVILLE WE	ST
	02-20-	97		BRET	A. ROBINSON	
EX						
						==*
		_		ondition Inf	ormation ========	* +
						- - •
	Reac	h Wate	r Surface	Friction		
#	Discha			Slope	Flow Re	egime
π 						- ,
1	1200	.00 **	****	.0029	Sub-Cri	itical
2	2040	.00 **	****	.0029	Sub-Cri	itical

Beginning 2 Profile Calculation(s) *

Federal Highway Administration - U. S. Geological Survey Model for Water-Surface Profile Computations.

Input Units: English / Output Units: English

I-70 OVER BR. MCCRACKEN CREEK I70-60-5180

COUNTY: HENDRICKS QUAD: MOORESVILLE WEST BRET A. ROBINSON

02-20-97

	WSEL	VHD	Q	AREA	SRDL	LEW
	EGEL	${\tt HF}$	V	K	FLEN	REW
	CRWS	HO	FR #	SF	ALPHA	ERR
Section: EXIT	751.712	.656	1200.000	263.807	*****	59065.390
Header Type: XS	752.369	*****	4.549	22267.84	*****	59238.120
SRD: .000	750.134	*****	.927	*****	2.040	*****
Section: FULLV	752.043	.526	1200.000	324.136	77.000	59049.680
Header Type: FV	752.569	.195	3.702	25590.38	77.000	59241.640
SRD: 77.000	750.134	.000	.789	.0025	2.469	.005

<< The Preceding Data Reflect The "Unconstricted" Profile >>>

===135 CONVEYANCE RATIO OUTSIDE OF RECOMMENDED LIMITS AT SECID "APPR ". KRATIO: .53

Section: APPR	753.337	.111	1200.000	529.590	212.000	59039.950
Header Type: AS	753.448	.871	2.266	13689.00	212.000	59358.390
SRD: 289.000	750.934	.000	.365	.0041	1.387	.008

<<< The Preceding Data Reflect The "Unconstricted" Profile >>>

<<< The Following Data Reflect The "Constricted" Profile >>> <<< Beginning Bridge/Culvert Hydraulic Computations >>>

	WSEL	VHD	Q	AREA	SRDL	LEW
	EGEL	HF	V	K	FLEN	REW
	CRWS	HO	FR #	SF	ALPHA	ERR
Section: BRDGE	751.858	1.122	1200.000	147.342		59192.330
Header Type: BR	752.980	.444	8.144	15551.75		59228.790
SRD: 77.000	751.261	.163	.745	*****		009
Specific Bridge Bridge Type 3 Pier/Pile Code	Information Flow Type 1 0	C .9590	P/A PFE: .038 759		XLAB 	XRAB * *******
	WSEL	VHD	Q	AREA	SRDL	LEW
	EGEL	HF	V	K	FLEN	REW

	CRWS		FR #	SF	ALPHA	ERR
Section: APPR	754.263		1200.000	835 850	77 000	59028 840
Header Type: AS						
SRD: 289.000						
_						
				raction Inf XRKQ		
M(G/			AUVĀ		OTEL	
.88	3 .573	3 1121	7.0 *****	** *****	754.263	
<<<	End of Br	ridge Hy	draulics Co	omputations	>>>	
*******	*******	* TAT C	D D O ***	*****	*****	***
Federal Hig						
_	_			Computatio		
				Units: Engl		
*						*
				I70-60-5180		_
COUNTY: HENI 02-20-97				T A. ROBIN		
02 20 37			2112	.1 110 1102111		
	WSEL	VHD	Q	AREA	SRDL	LEW
	EGEL		V	K		
				SF	ALPHA	ERR
Section: EXIT			2040.000		*****	59019.860
Header Type: XS						
SRD: .000	752.094 *	****	.834	*****	3.485	****
Costion. EULIV	752 207	610	2040 000	621.753	77 000	E0017 000
Section: FULLV Header Type: FV				43469.11		
SRD: 77.000				.0025		
<<< The Pre	ceding Dat	a Refle	ct The "Und	constricted	" Profile	>>>
Section: APPR	754.528	.127	2040.000	927.754	212.000	59025.660
Header Type: AS	754.655	.660	2.199	30769.78		59375.660
SRD: 289.000	752.528	.000	.309	.0031	1.682	010
<<< The Pre	ceding Dat	a Refle	ct The "Und	constricted	" Profile	>>>
<<< The Fo	llowing Da	ta Refl	ect The "Co	onstricted"	Profile >	>>>
				lic Computa		
===210 QUESTIONABLE				SECID "BRDG	Е".	
Q, CRWS:	2040.00	753.	23			
	WSEL	VHD	Q	AREA	SRDL	LEW
	EGEL	HF	v	K	FLEN	REW
	CRWS	НО	FR #	SF	ALPHA	ERR

Section: BRDGE						
	753 235	1 021	2040 000	201 262	77 000	E0100 /10
Header Type: BR						
SRD: 77.000						
SKD: 77.000	755.255		.054		1.202	
Specific Bridge	Information	n C	P/A PFE	LEV BLEN	XI.AR	YRAR
Bridge Type 3						
Pier/Pile Code				.000 *****		
	WSEL	VHD	0	AREA	SRDL	LEW
			v	K		
				SF		
Section: APPR	756.518	.045	2040.000	1676.461	77.000	59002.820
Header Type: AS	756.563	.245	1.217	73940.25	90.445	59404.520
SRD: 289.000	752.528	1.162	.147	.0031		.009
203.000	,52.526		,,			
Apr	roach Secti	on APPR	Flow Cont	raction Info	rmation	
				XRKQ		
	879 .71	L7 2083	33.6 *****	** ******	756.518	
<	<< End of E	Bridge Hy	draulics C	omputations	>>>	
		-	•	-		
*******	*****	*** W S	DRO ***	*****	******	***
Hodowal I		,, ,	INO			
rederar r	lighway Admi			S. Geologica		
		inistrati	ion - U.		l Survey	
Mo	del for Wat	inistrati er-Surfa	ion - U. ace Profile	S. Geologica Computation	l Survey	
Mo	del for Wat	inistrati :er-Surfa English	ion - U. ace Profile	S. Geologica Computation Units: Engli	l Survey	*
Mc Ing *	odel for Wat out Units: F	inistrati cer-Surfa English	ion - U. ace Profile / Output	S. Geologica Computation Units: Engli	l Survey	*
Mo Ing *I-70	odel for Wat out Units: F	inistrati cer-Surfa English CCRACKEN	ion - U. ace Profile / Output CREEK	S. Geologica Computation Units: Engli	ol Survey	*
Mo Ing *I-70	odel for Wat out Units: F OVER BR. MO ENDRICKS	inistrati cer-Surfa English CCRACKEN	ion - U. ace Profile / Output CREEK QUAD:	S. Geologica Computation Units: Engli	al Survey as. sh WEST	*
Mo Ing * I-70 COUNTY: H	odel for Wat out Units: F OVER BR. MO ENDRICKS	inistrati cer-Surfa English CCRACKEN	ion - U. ace Profile / Output CREEK QUAD:	S. Geologica Computation Units: Engli I70-60-5180 MOORESVILLE	al Survey as. sh WEST	*
Mo Ing * I-70 COUNTY: H	odel for Water to the Court Units: For Court Water BR. MC ENDRICKS	inistrati cer-Surfa English CCRACKEN	ion - U. ace Profile / Output CREEK QUAD: BRE	S. Geologica Computation Units: Engli I70-60-5180 MOORESVILLE ET A. ROBINS	al Survey as. sh WEST	*
Mo Ing * I-70 COUNTY: H 02-20-	odel for Water to the Court Units: For Court Water BR. MC ENDRICKS	inistrati cer-Surfa English CCRACKEN	ion - U. ace Profile / Output CREEK QUAD: BRE	S. Geologica Computation Units: Engli I70-60-5180 MOORESVILLE ET A. ROBINS	al Survey as. sh WEST	*
Mo Ing * I-70 COUNTY: H 02-20-	odel for Water Doubt Units: For the Contraction of the Contraction	inistrati cer-Surfa English CCRACKEN	ion - U. ace Profile / Output CREEK QUAD: BRE	S. Geologica Computation Units: Engli 170-60-5180 MOORESVILLE ET A. ROBINS for Header	al Survey as. sh WEST	*
Mo Ing * I-70 COUNTY: H 02-20-	odel for Water Doubt Units: For the Contraction of the Contraction	inistrati cer-Surfa English CCRACKEN	ion - U. ace Profile / Output CREEK QUAD: BRI alculations	S. Geologica Computation Units: Engli 170-60-5180 MOORESVILLE ET A. ROBINS for Header	al Survey as. sh WEST	*
Mc Ing *	odel for Water Doubt Units: For Constant Constan	inistraticer-Surfa	con - U. Ace Profile / Output CREEK QUAD: BRI Alculations Input Vari	S. Geologica Computation Units: Engli 170-60-5180 MOORESVILLE ET A. ROBINS for Header	as. sh WEST ON Record BE	*
Mc Ing *	odel for Water Doubt Units: For OVER BR. Moreover BR. Mor	inistration in the control of the co	con - U. ace Profile / Output CREEK QUAD: BRI alculations Input Vari	S. Geologica Computation Units: Engli 170-60-5180 MOORESVILLE ET A. ROBINS for Header ables	al Survey as. sh WEST ON Record BE	*
Mc Ing *	odel for Water Doubt Units: For OVER BR. Moreover BR. Mor	inistration in the control of the co	con - U. Acce Profile / Output CREEK QUAD: BRI BRI Cloulations Input Vari	S. Geologica Computation Units: Engli	sl Survey ss. sh WEST ON Record BE	*
MC Ing * I-70 COUNTY: H 02-20- *** Live-Bed C	odel for Water Units: Hout Units: Hout Units: House BR. More ENDRICKS 97 Contraction Constant	English CCRACKEN Scour Ca ants and Cransport	CREEK QUAD: BRI BRI BLULATIONS Input Vari	S. Geologica Computation Units: Engli	al Survey as. sh WEST ON Record BE	*
MC Ing * I-70 COUNTY: H 02-20- *** Live-Bed C	odel for Water Units: Hout Units: Hout Units: House BR. More ENDRICKS 97 Contraction Constant	English CCRACKEN Scour Ca ants and Cransport	CREEK QUAD: BRI BRI BLULATIONS Input Vari	S. Geologica Computation Units: Engli I70-60-5180 MOORESVILLE ET A. ROBINS for Header ables or (k1): (Pw): 3.	al Survey as. sh WEST ON Record BE	*
MC Ing * I-70 COUNTY: H 02-20- *** Live-Bed C	odel for Water Doubt Units: For Sout Units: For South Uni	Enistration of the control of the co	CREEK QUAD: BRI BRI BRI BRI BRI Comput Vari Mode Fact	S. Geologica Computation Units: Engli 170-60-5180 MOORESVILLE ET A. ROBINS for Header ables or (k1): (Pw): 3.	Survey s. sh WEST ON Record BE * .64 000*	* RDGE ***
MC Ing * I-70 COUNTY: H 02-20- *** Live-Bed C * Bed Tot	odel for Water Dut Units: For Sout Units: For Sout Units: For Water South Endricks Gontraction Constant South Endrich South En	Enistration of the control of the co	CREEK QUAD: BRI BRI BRI BLULIATIONS Input Vari Mode Fact	S. Geologica Computation Units: Engli 170-60-5180 MOORESVILLE ET A. ROBINS for Header ables or (k1): (Pw): 3.	Survey as. sh WEST ON Record BE * .64 000*	* RDGE ***
Tot Scour Bed Tot	Odel for Water Dut Units: For Solution Constant Approace	Enistration of the Control of Con	CREEK QUAD: BRI Cloudations Input Vari Mode Fact Width Fact Approa	S. Geologica Computation Units: Engli 170-60-5180 MOORESVILLE ET A. ROBINS for Header ables or (k1): (Pw): 3.	Survey S. Sh WEST ON Record BE * .64 000* C-Limits Contract BE	RDGE ***
Tot Scour Scour L-70 Mo Ing 1-70 COUNTY: H 02-20- *** Live-Bed County * Bed Tot * Scour # Depth Contr	Odel for Water Dut Units: For Solution Constant Approace	Enistration of the Control of Con	CREEK QUAD: BRI Cloudations Input Vari Mode Fact Width Fact Approa	S. Geologica Computation Units: Engli I70-60-5180 MOORESVILLE ET A. ROBINS for Header ables or (k1): (Pw): 3.	Survey S. Sh WEST ON Record BE * .64 000* C-Limits Contract BE	RDGE ***
Tot Scour Bed Tot	OVER BR. MO ENDRICKS 97 Contraction Consta	Enistration of the Control of the Co	CREEK QUAD: BRI alculations Input Vari Mode Fact Width ract Approa	S. Geologica Computation Units: Engli 170-60-5180 MOORESVILLE ET A. ROBINS for Header ables or (k1): (Pw): 3.	Survey Is. Ish WEST ON Record BE .64 000 Chimits Contract E	RDGE *** Approach
# Depth Contr	OVER BR. MO ENDRICKS 97 Contraction Consta Material 7 Cal Pier Wide Flow Fact Approace 000 690.7	Enistration of the control of the co	CREEK QUAD: BRI alculations Input Vari Mode Fact Width ract Approa	S. Geologica Computation Units: Engli 170-60-5180 MOORESVILLE ET A. ROBINS for Header ables or (k1): (Pw): 3. ch Side Computation On Left: * Right: *	Survey s. sh WEST ON Record BE * .64 000* Chimits *******	Approach
# Depth Control 17.762 1200 Approace	OVER BR. MO ENDRICKS 97 Contraction Constant Material Teler Wide al Pier Wide Flow Fact Approace 000 690.7	Enistration of the control of the co	CREEK QUAD: BRI Alculations Input Vari Mode Fact Width Fact Approa	S. Geologica Computation Units: Engli 170-60-5180 MOORESVILLE ET A. ROBINS for Header ables or (k1): (Pw): 3. ch Side C 100 Left: * 100 Left: *	Survey Is. Ish WEST ON Record BE * .64 000 * Chimits contract ********	Approach

```
********************* W S P R O ***************
     Federal Highway Administration - U. S. Geological Survey
          Model for Water-Surface Profile Computations.
          Input Units: English / Output Units: English
   *-----
        I-70 OVER BR. MCCRACKEN CREEK I70-60-5180
     COUNTY: HENDRICKS
                              QUAD: MOORESVILLE WEST
       02-20-97
                                BRET A. ROBINSON
      *** Pier Scour Calculations for Header Record BRDGE ***
                Constants and Input Variables
                  Pier Width: 1.500
          *----*
           Pier Shape Factor
                                 (K1): 1.00
           Flow Angle of Attack Factor (K2): 1.00
           Bed Condition Factor (K3): 1.10
           Bed Material Factor
                                (K4): 1.00
                                (VM): 1.00
           Velocity Multiplier
           Depth Multiplier
                                (YM): 1.00
          *----*
   Scour ---- Localized Hydraulic Properties ---- X-Stations --
         Flow WSE Depth Velocity Froude # Left Right
  Depth
  .....
        1200.000 752.776 6.876 9.386
                                    .631 59175.000 59244.000
1
   4.61
  5.28 2040.000 754.397 8.497 12.004 .726 59175.000 59244.000
   ******************** W S P R O ****************
     Federal Highway Administration - U. S. Geological Survey
          Model for Water-Surface Profile Computations.
         Input Units: English / Output Units: English
          I-70 OVER BR. MCCRACKEN CREEK
                                 170-60-5180
    COUNTY: HENDRICKS
                              QUAD: MOORESVILLE WEST
       02-20-97
                                BRET A. ROBINSON
      *** Pier Scour Calculations for Header Record BRDGE ***
                Constants and Input Variables
                  Pier Width: 1.500
          *----*
                           (K1): 1.00
           Pier Shape Factor
           Flow Angle of Attack Factor (K2): 1.00
                               (K3): 1.10
           Bed Condition Factor
                                (K4): 1.00
           Bed Material Factor
           Velocity Multiplier (VM): 1.00
Depth Multiplier (YM): 1.00
          *----*
```

	Scour Localized Hydraulic Properties					es	X-Stations			
#	Depth	Flow	WSE	Depth	Velocity	Froude #	Left	Right		
1	4.61	1200.000	752.776	6.876	9.386	.631	59175.000	59244.000		
2	5.28	2040.000	754.397	8.497	12.004	.726	59175.000	59244.000		
E	R									
********** Normal end of WSPRO execution. **********										
	*****	***** El	apsed Tir	ne: 0	Minutes	5 Seconds	s ******	*****		